

Trade Openness And Environmental Challenges: The Essential Role Of Government In South Asian Developing Countries

Farrukh Ishtiaq*

School of Economics and Trade, Hunan University, Changsha, China

Email: farrukhishtiaq551@gmail.com & <http://orcid.org/0009-0007-9903-8998>

Deng Aimin

School of Economics and Trade, Hunan University, Changsha, China

Email: aimindeng@hnu.edu.cn

Abstract

Global warming is alarming issue for all over the world. So, it's necessary to point out this issue to solve the problem of environmental degradation. This paper explains the existence of pollution heaven hypothesis in south Asian developing countries for the period of 1997 to 2022. This study uses the fixed effect model for analysis. The results showed that Trade openness, foreign direct investment, gross domestic product and non-renewable energy consumption are harmful for environment. Renewable energy consumption is environment friendly because there is decrease in carbon emissions due to renewable energy consumption. The results shows that there is existence of pollution heaven hypothesis in south Asian developing countries. It means that due to trade openness there is increase in carbon emission in south Asian countries. All the variables included in the model are positive and statistically significant except renewable energy consumption. By using interaction term between trade openness and government effectiveness, it is observed that carbon emission is decreased due to government effectiveness. There should be environment friendly technologies and strict rules and regulations in case of trade that's why we can reduce carbon emissions. The role of government is necessary to protect the environment.

Keywords: Trade Openness, Environmental Degradation, Government Effectiveness, Pollution Heaven Hypothesis, Fixed Effect Model, South Asian Countries

Introduction

Asia is facing environmental degradation problem since last many years. Some previous studies conducted in Asia to check the impact of trade openness, economic growth, foreign direct investment, energy consumption on environment degradation. Grossman and Krueger (1993,1995) first time introduced the relationship between international trade, economic growth and the environment. This study explains the relationship between international trade and environment into three effects:

composition effect, scale effect and technique effect. Scale effect means when production of a country increased when demand increased due to increase in international product demand composition effect means resources of a country and technique effect means used of technology in production process. According to these studies: Bernard, J. and Mandal, S. K. (2016), Hultberg, P. (2018), Rehman et al., (2022) Li, et al., (2022) trade has negative impact on environment. If there will be more trade environment will be degraded. These studies showed that trade is beneficial because trade is environment friendly in these countries. Orhan, et al., (2021), Ramcke; Ramcke. (2009).

There is no long run relationship between economic growth and carbon emissions because countries try to use some advance technologies that are environment friendly. In the short run there is positive relationship between economic growth and carbon emissions. Some previous studies showed that there are some mixed results. Government can play important roles to reduce carbon emissions by implementing strict rules and regulations and policies related to environment. If government is effective and want to reduce carbon emission they can use renewable energy consumption. Because if countries will depend on fossil fuels there will be environmental degradation. If they rely on renewable resources then can save their environment. If government impose energy efficiency program, they can also reduce carbon emissions. If government is effective, they will agree with international corporations and because of this they can reduce global carbon emissions.

South Asia is the world's significant portion of the population and it is contributing in the environmental problems. Environmental degradation is affecting health through air and water pollution. Studying environmental degradation will be helpful how we can save environment. Country cannot grow with environmental degradation so it is necessary to study environmental degradation because policy maker can make polices related to environment. Due to environmental degradation, there is climate change, increase in temperature due to use of greenhouse gasses in south Asian countries so if we will study environment degradation, we can recommend polices that can help to save the environment. As argued by Stern and Common (2001), estimates from developed countries may not be informative about future development of emissions in developing countries, particularly when fixed effects estimators are employed. Some studies were conducted in developed countries to check the impact of trade and economic growth on environmental degradation. Ahmed et al., (2014) estimates the existence of environmental Kuznets curve in Pakistan for the period of 1980 to 2013 by using ARDL. The results showed that there is cointegration between short run and long run. Vincent, J. R. (1997) investigated the relationship between economic growth and carbon emission. Is there existence of environmental Kuznets curve in Malaysia. There is water and air pollution in Malaysia.

The present study therefore makes a contribution to the debate on the impact of trade openness and government effectiveness in south Asian developing countries. For the first time this research will be conducted in south Asian developing countries by using these variables. This study will be helpful for policy makers to save the environment. This study will be beneficial to people in order to infer the importance of environment.

How these developing countries can promote their trade and how they can grow by using green technologies. How these countries can save their environment. And it will be source of awareness for people to know about impacts of different human activities. This research provides them a wider spectrum to narrow the idea of any environmental problem. This study for the first time checks the impact of trade openness and foreign direct investment on environmental degradation with these variables in south Asian developing countries.

The novelty of the study is that there is no study conducted with such variables in south Asian countries. This study for the first time checks the role government with interaction term with trade openness. This study uses different methodology for analysis. The most recent data will be used for analysis. There is global warming in these countries so on behalf of this study we can recommend such strong policy implications that how we can protect our environment by using environment friendly technologies and by implying such rules and regulation.

Literature Review

Shahbaz et al., (2013) analyzed the impact of trade, energy and economic growth on co2 for the time period 1971-2009. Granger causality and ARDL was used for estimation. There is existence of Environmental Kuznets curve in these countries. Environment and energy are negatively correlated with each other, but there is decrease in environment due to trade. Akin (2014) checked the impact of trade, energy consumption and GDP on carbon emissions for the time period of 1990-2011. Ordinary least square, FMOLS, DOLS and VECM were used for estimation. Result showed that there is positive relationship between energy use and carbon emissions. There is increase in carbon emissions due to economic growth and there is inverse relationship between trade and carbon emissions.

Al-Mulali et al., (2015) checked the relationship between trade openness and carbon emissions for the time period 1980 to 2011. Granger causality and DOLS was used for estimation and Results showed that there decrease in carbon emissions in middle- and high-income countries but there is adverse effect on environment in lower income countries. Keho (2016) investigated the impact of trade on environment. There is positive impact of trade on environment. Environment will be better due to trade in Benin and Gambia. But in Burkina Faso, Ghana, Senegal, and Togo environment will be affected.

Bernard and Mandal, (2016), analyzed the impact of trade on environment quality. Trade is dependent variable and Foreign direct investment, Gross domestic product, Governance, Political globalization, urbanization and financial development are independent variables in this study. This study was conducted in 60 emerging countries from Latin America, Asia, Africa and Europe. The time period of data is 2002-2012 and data is collected from US Energy Information Administration, UNCTAD, KOF Index of globalization, World Governance Indicators and World Bank Development Indicators. Carbon dioxide as a dependent variable, trade openness, Gross domestic product, financial development, Foreign direct investment, Energy consumption, Governance, political globalization and Urbanization as an

explanatory variable in analysis. Fixed model effect and GMM estimation technique were used for analysis. There is existence of environmental Kuznets curve because increase in per capita income leads to carbon emissions. Energy consumption has also positive impact on carbon emissions. All the variables have positive impact on carbon emissions excluding governance and political globalization. If there is good governance so environment will be healthy in these countries.

Hultberg, (2018), investigated the impact of trade openness and economic growth on carbon emissions by using the theoretical trade model. Data was collected from six Asian developing countries because these countries are expanding their trade day by day and pollute environment continuously. Panel data was used for analysis and time period of data is 1986-2013. Carbon emission is dependent variable, trade openness and economic growth are independent variables. Fixed effect panel regression model was used to check the relationship between dependent and independent variables. There were two model in this study, the first model showed that there is negative impact of trade openness on environment. Empirical results showed that 1% increase in trade will leads to 1.06% increase in carbon emissions. Second model showed that there is existence of environmental Kuznets curve due to economic growth environment will be damaged. The model with square term explained that there is no inverted u-shaped Kuznets curve in these countries. In the start due to economic growth environment will affect but while reaching at the certain level it will improve the environment. The limitation of the study is further researcher can take the proxies of environment as methane, sulfur dioxide and nitrous dioxide.

Rehman et al., (2022) checked the relationship between renewable energy consumption, urbanization, trade and economic growth on carbon emission in Maldives. Carbon emission is dependent variable and renewable energy consumption, trade, urbanization and economic growth are independent variables. This study used yearly data from world development bank for the period of 1990 to 2020. Non-linear autoregressive distributive lag (NARDL) model was used for analysis. This study checked the short run and long run relationship between variables by using NARDL model. The results showed that economic growth and renewable energy has positive links with carbon emissions similarly trade has positive linkages between carbon emission in short run and long run. While urbanization has negative link between carbon emission in Maldives. He, S. (2019), evaluated the impact of trade on environmental quality in China. Time period of data is 1997 to 2008, to check the relationship between variables. The objective of the study is to check the impact of trade on environment performance in case of three effects: scale effect, composition effect and technique effect. Author used panel regression techniques for estimation. The study showed that trade has positive and significant impact on environment.

Salaman et al., (2024) examines the relationship between free trade agreement and carbon emissions in Pakistan for the period of 1980 to 2014. Fully modified ordinary least square results showed that there is positive impact of gross domestic product on carbon emissions in Pakistan. In the long run there is negative relationship between trade openness and free trade agreement. But there is increase in carbon emission due to use to energy consumption in Pakistan. Li et al., (2022) investigated the

relationship between trade openness and environment. Data for 98 countries was taken for the period of 1980 to 2013 to check the relationship between variables such as particulate matter emissions (PA), GDP, GDP², Trade openness (TO). Panel integration results showed that there is long run relationship between trade openness, economic growth and particulate matter emissions. There is positive and significant impact of trade openness on environmental degradation. But in high income countries there is mild effect of trade openness on environmental degradation but in low-income countries the effects are harmful. So trade is beneficial for high income countries.

Fang et al., (2020) investigate the impact of trade openness and economic growth on the environment. This study used the data of 261 cities of China for the period of 2004 to 2013. Sulfur dioxide and Industrial waste water are used as a pollutant in this study. GMM and cup-FM results showed that there is no existence of environmental Kuznets curve over all but in some cities there's evidence of environmental Kuznets curve. Those cities have more openness face more industrial waste water and sulfur dioxide pollutants. Cities with less openness have less industrial waste water and sulfur dioxide pollutants.

Kamaci et al., (2021) discovered unidirectional causality between trade openness and carbon emissions and one-way causality between foreign direct investment and carbon emission. The time period of data is 1995 to 2019, 24 European union countries were selected for studies including Austria, Denmark, Poland, Spain, Czech, Germany, Italy, Belgium, Switzerland, Latvia, Finland, Bulgaria, Slovenia, Ireland, Estonia, Slovakia, Portugal, Croatia, Romania, Republic, Netherlands, France, Lithuania, Greece and Hungary. This study used Expanded mean group (EMG) for analysis. The results showed that there is unidirectional relationship between carbon emission and trade openness in Italy, France, Germany, Likewise, Switzerland, Bulgaria, Austria, Spain, Denmark, Portugal, Latvia, Poland, Finland, Slovenia and Estonia. There is one-way causality relationship between Foreign direct investment and carbon emissions in some countries. So, trade openness and foreign direct investment has significant impact on carbon emissions in some countries.

Managi et al., (2008) investigated the impact of trade, economic growth on environmental degradation in OECD and non-OECD countries. There are two endogenous variables trade and income and used instrumental technique to check the impact of trade openness on environment quality. Results showed that there is negative impact of trade on environment in OECD countries. Its mean trade is beneficial for environment in OECD countries. There is positive impact of trade on sulfur dioxide and carbon dioxide in non-OECD countries. Trade is harmful for non-OECD countries. Non-OECD countries can improve their environment by imposing environment rules and regulations.

Shahbaz et al., (2017) analyzed the relationship between trade openness and carbon emissions in 105 countries categorized as low income, middle income and high-income class. Panel co-integration test was used for analysis and results showed that there is relationship between the variables in the long run but the relationship depends on country wise. Trade openness is more environment friendly but depends on country situation. In case of low-income countries trade openness has more impact on

environmental degradation but in case of middle- and high-income countries the effect is less. Adams and Opoku, (2020) checked the relationship between trade and carbon emissions in 22 Sub Saharan African countries for the period of 1995 to 2014. The study showed that there is positive impact of trade on carbon emissions in these countries. From these results these countries can make policy related to environment.

Data And Methodology

In a research data and methodology is important. In this chapter we will explain conceptual framework, mathematical equation, econometric model, data description, data source, econometric techniques.

Mathematical Equation

The mathematical equation of the study is as follows:

$$CO_2 = f(TO, FDI, GDP, REC, NREC)$$

$$CO_2 = f(TO*GE, FDI, GDP, GDPsq, REC, NREC)$$

Econometric Equation

The Econometric equation of the study is as follows;

$$CO_{2it} = \beta_0 + \beta_1 TO_{it} + \beta_2 FDI_{it} + \beta_3 GDP_{it} + \beta_4 REC_{it} + \beta_5 NREC_{it} + \epsilon_{it}$$

$$CO_{2it} = \beta_0 + \beta_1(TO*GE)_{it} + \beta_2 FDI_{it} + \beta_3 GDP_{it} + \beta_4 GDP^2_{it} + \beta_5 REC_{it} + \beta_6 NREC_{it} + \epsilon_{it}$$

Methodology

This study will use panel data for analysis and fixed effect model will be used for estimation.

Fixed Effect Method

Fixed effect and random effect are model that are used to analyze the relationship between variables in panel data. Fixed effect model is used for analysis when individual effects are unique and constant to each entity and individuals and it will not change across the time. In fixed effect model parameters are same for all groups and they are consistent and there is no randomness in parameters.

Data Descriptions

Table 1 shows the description of the variables that are used in the research.

Table 1 Description of the Variables

Variables	Description	Measurement	Data Source
CO ₂	Carbon emissions capita	metric tons per	WDI
TO	Trade Openness GDP	% of	WDI
FDI	Foreign direct investment inflows	Net	WDI

REC	Renewable energy total EC	% of	WDI
GDP	Gross Domestic Product US\$	Current	WDI
NREC	Non-renewable energy total EC	% of	WDI
GDP ²	GDP square US\$	Current	WDI
GE	Government Estimate	Effectiveness	WDI
Source: Organized by Authors			

Data Analysis and Results Interpretation

Diagnostic Tests

Analysis of Multicollinearity

When there is relationship between independent variables in a regression model this problem is called Multicollinearity. If the explanatory variables are strongly correlated with each other there will be perfect multicollinearity between the variables. If we will calculate the correlation matrix if the value of correlation matrix is 0.7 or 0.8 there will be problem of multicollinearity. The value of coefficient correlation is -1 to +1. If the value is close to 1 there will be perfect collinearity between the variables. So you should increase the data size or remove the variable from the model. In this model we use pair wise correlation matrix and variation inflation factor (VIF) to check the multicollinearity.

Pair-Wise Correlation Matrix

The table 2 shows the results of pair wise correlation matrix of all the variables included in the model. The value of coefficient correlation lies from 1 to -1. If the value is close to 1 or positive there will be perfect multicollinearity between the variables, its mean explanatory variables are correlated with each other. If the value is negative there will be negative multicollinearity between the variables. If the values lie between 0 to 3 there will be correlation between the variables. If the value is zero there is no multicollinearity between the variables. The correlation between TO and CO2 is 0.70435 its mean that if there will be 1% increase in TO there will 0.70435% increase in CO2. The value of coefficient correlation is positive and close to 1. The coefficient correlation of FDI and CO2 is 0.76997, there is strong collinearity between these two variables. The correlation between GDP and CO2 is 0.13072, so the value is close to zero so there is week correlation. NREC and CO2 have the correlation of 0.21229 which lies between 0 to 3 its mean that there is week correlation between variables. The correlation between REC and CO2 is -0.5051.

Table 2: Results of Pair – Wise Correlation Matrix of all Variables in Model 1

	CO2	TO	FDI	GDP	REC	NREC
CO2	1					
TO	0.70435	1				
FDI	0.76997	0.57997	1			
GDP	0.13072	0.05890	0.17765	1		
REC	-0.5051	-0.11975	-0.5374	-0.0792	1	
NRE	0.21229	-0.16651	-0.0454	0.02595	-0.1433	1

Source: Author’s Calculations

The correlation between FDI and TO is 0.57997 which shows there is strong correlation between variables. The correlation between GDP and TO is 0.05890 which is positive but shows weak correlation between gross domestic product and trade openness. The correlation between NREC and REC is -0.16651 and -0.11975 which is negative. The correlation between of FDI with REC and NREC is 0.17765, -0.5374 AND -0.0454 which shows the weak correlation. The correlation of GDP with REC and NREC is -0.0792 and 0.02595 which the weak correlation between the variables. The correlation between REC and NREC IS -0.1433 which is negative and its shows the weak correlation between the variables.

Variance Inflation Factor

Through variance inflation factor we can detect the multicollinearity in the regression model. Variance inflation factor calculate the collinearity in the model for the predictors. Variation inflation factor tells us how much variance is inflated due to collinearity in the model. The value of variation inflation factors lies between 1 to 10. If VIF is equal to 1 there is no multicollinearity, if the value of VIF is between 1 to 5 there is low multicollinearity between the variables. If the value of VIF is greater than 5 or close to 10 there is severe problem of multicollinearity in the regression model.

Table 3: Results of Variance Inflation Factor (VIF) of all Variables in Model 1

Variance Inflation Factor (VIF)	
Variables	Centered VIF
TO	1.665501
FDI	2.333311
GDP	1.038155
NREC	1.060775
REC	1.567608
C	NA

Source: Author’s Calculations

Above table 3 shows the results of detection of multicollinearity by using variation inflation factor(VIF). The above table shows that there is no multicollinearity in all variables because values are equal to one except Foreign direct investment. Trade openness has VIF (1.665501), FDI has (2.333311), DGP (1.038155), NREC (1.060775) and REC has (1.567608). There is no multicollinearity in this model.

Analysis of Autocorrelation

When there is relationship between variables current periods and previous period. When there is relationship between error term and other variables. Autocorrelation mostly exist is time series data. The value of autocorrelation shows that if it is +1 there will be positive autocorrelation and if the value is -1 there is negative autocorrelation in the data set. In this model used LM test to detect the autocorrelation in the data set. The hypothesis of autocorrelation is as follows:

Null Hypothesis(H_0)= no autocreation

Alternate Hypothesis(H_1)= autocreation

If the probability value is insignificant and greater than 0.05% so we will accept the null hypothesis its mean there is no autocorrelation. If the probability value is significant and less than 0.05% so we will accept the alternate hypothesis its mean there is problem of autocorrelation.

Table 4: The Results of Serial Correlation LM test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.2665	Prob. F(2,226)	0.7725
Obs*R-squared	0.757695	Prob. Chi-Square(2)	0.6847

Source: Author’s Calculations

The above table 04 shows the results of detection of autocorrelation by using LM test. The results shows that the probability value is insignificant and greater than 0.05% which is 0.7725. SO, the results showed that we will accept the null hypothesis its mean there is no autocorrelation in the data set.

Analysis of Heteroskedasticity

If the variance of residual is unequal there will be problem of heteroskedasticity. If we omitted a variable that can affect the dependent variable, of the functional form is not correct, if there are outliers in the data set, we can face the problem of heteroskedasticity. If there is problem of heteroskedasticity in the data set there, will be it will affect the accuracy of the model. So here we used Breush Pagan Godfrey test to detect the problem of heteroskedasticity. The hypothesis of Heteroskedasticity is as follows

Null Hypothesis (H_0) =No Heteroskedasticity

Alternate Hypothesis (H_1) = Heteroskedasticity

If the probability value is insignificant and greater than 0.05%, we will accept null hypothesis its mean that there is no problem of Heteroskedasticity. If the probability

value is significant and less than 0.05%, we will accept alternate hypothesis it means that there is problem of Heteroskedasticity.

Table 5: The Results of Breusch-Pagan-Godfrey test
Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.526686	Prob. F(62,8)	0.8571
Obs*R-squared	6.148049	Prob.Chi-Square(10)	0.8027
Scaled explained SS	3.470994	Prob.Chi Square(10)	0.9681

Source: Author's Calculations

The above table 5 shows that the probability value is insignificant and greater than 0.05% which is 0.8571. So here we will accept null hypothesis, its mean that there is no problem of Heteroskedasticity.

Analysis of Hausman Test

The difference between fixed effect and random effect is called Hausman test. The test will tell us fixed effect is better or random effect is better. If we will reject alternate hypothesis then fixed effect is better and if we will reject null hypothesis fixed effect is better. If the probability value is greater than 0.05% then random effect test is better and if the probability value is less than 0.05% then fixed effect is better than random effect test. There is below hypothesis of Hausman test.

Null Hypothesis(H0)= Randon effect is better than fixed effect

Alternate Hypothesis(H1)=Fixed effect is better than random effect

This test tells us if the probability value is greater than 0.05% we will accept null hypothesis its mean that random effect is better than fixed effect. If the probability value is less than 0.05% then we will reject the null hypothesis and accept the alternate hypothesis its mean that fixed effect is better than random effect.

Table 6: The Result of Hausman Test

Correlated Random Effects - Hausman Test

Equation: Untitled

Test period random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Period random	103.9278	5	0

Source: Author's Calculations

The above table 6 shows the results of Hausman test. The results show that the probability value is less than 0.05% so here we will reject the null hypothesis and accept the alternate hypothesis So fixed effect is better than random effect.

Analysis of Redundant Fixed Effects Test

The difference between common constant method and fixed effect method is called Redundant fixed effects test. Through this test we can decide which test is suitable for

our analysis. So the probability value is greater than 0.05% we will reject the alternate hypothesis and accept the null hypothesis, its mean the common constant method is better than the fixed effect method. If the probability value is less than 0.05%, we will reject null hypothesis and accept alternate hypothesis its mean that fixed effect test is better than common constant test. The hypothesis of Redundant fixed test is as follows

Null Hypothesis (H0)= Common constant effect is better than fixed effect test

Alternate Hypothesis (H1)= Fixed effect test is better than common constant test

Table 7: The Results of Redundant Fixed Effects Test

Redundant Fixed Effects Tests			
Equation: Untitled			
Test cross-section fixed effects			
Effects Test	Statistic	d.f.	Prob.
Cross-section F	34.89341	-7203	0
Cross-section Chi-square	170.6228	7	0

Source: Author's Calculations

The above table 7 shows that the probability value is less than 0.05%, So we will reject the null hypothesis and accept the alternate hypothesis. Its mean that the fixed effect test is better than the common constant method.

Results of Fixed Effect Regression Analysis

Fixed effect model is used to check the relationship between dependent and independent variable in panel data. Here we are applying fixed effect regression model to check the relationship between carbon emissions and trade openness in south Asian developing countries. The results of fixed effect regression model are presented in table 8. So, we will explain the relationship between carbon emissions, trade openness, gross domestic product, foreign direct investment, non-renewable energy consumptions and renewable energy consumption in south Asian developing countries. The coefficient of trade openness shows positive and statistically significant impact of trade openness on carbon emission with the value of 0.0049. Its mean that 1% increase in trade openness will lead to increase in carbon emissions by 0.039711. The relationship between trade openness and carbon emissions in south Asian countries is positive because in developing countries there are no rules and regulations. These countries want to grow more and they didn't impose any rule and regulations in case of trade. If countries want to grow more, they will increase their production so there will be more environmental degradation. In developing countries there is also no rules and regulation and strict polices related to environment. There are three types of effect in case of trade. Scale effect means if a country is growing and due to increase in production and consumption will lead to increase in carbon emissions. Composition effect means that if a country is using more carbon industries there will be increase in carbon emissions. Technique effect means that if a country is

using more efficient and environment friendly technologies that can be decrease carbon emissions. So in south Asian countries there will be scale effect. So, there is existence of pollution heaven hypothesis in south Asian developing countries. This result is similar to Rehman et al., (2022) and Hultberg, (2018) because there is also negative impact of trade openness in environmental degradation in six Asian developing countries and Maldives. The coefficient of foreign direct investment is positive and significant with the value of 0.084. One % increase in foreign direct investment will leads to increase in carbon emissions by 0.017173. If companies' investment in host countries without environmental regulations this can be lead carbon emissions due to foreign direct investment. If foreign countries and companies invest in oil, mining and gas due to fossil fuels there will be increase in carbon emissions. Infrastructure Project related to foreign direct investment e.g. power plants and highways can increase carbon emission due to use in energy. Projects related to industries can also increase carbon emissions. This result is similar to Shao, Y. (2017) because in 188 countries there is negative impact of foreign direct investment on carbon emissions. The coefficient of gross domestic product shows the positive and significant impact carbon emission with the value of 0.0202. If there will be 1% increase in gross domestic product will lead to increase in carbon emission by 0.003986. Gross domestic product is proxy of economic growth, so if a country is growing its mean that there will be increase in transportation, infrastructure and expansion in manufacturing. So, all these things lead to increase in energy demand so due to this there will be environmental degradation. If a country is growing the consumption pattern of the country will change, people will change their living standard, their demand will change so because of this there will be increase in production and environment will be degraded. Urbanization is also a factor that will lead to increase in carbon emissions because people will move from one place to another place there will be increase in construction of building, infrastructure and development. These results are similar to Ben jebli et al., (2014), Dizaji et al. (2016) and Mikayilov et al., (2018) there will be increase in carbon emissions due to economic growth. The coefficient of renewable energy consumption is negative but statistically significant with the value of 0.000. If one% in renewable energy consumption will lead to decrease in carbon emission by -0.03837. Due to use of renewable energy consumption instead of fossil fuels decrease carbon emissions. If countries will produce electricity by using hydro and wind turbines due to this renewable energy there will be less carbon emissions. The coefficient of non-renewable energy consumption is positive and statistically significant with the value of 0.008. If 1% increase is nonrenewable energy consumption will lead to increase in carbon emissions by 0.005801. The sources of renewable energy consumption such as oil, coal and natural gas are the major contributor to carbon emissions. When a country use to produce electricity and other things they use nonrenewable energy consumption sources and they release carbon dioxide and other green gas and due to this there is impact on environment and climate change.

Table 8: The Results of Fixed Effects Regression Analysis

Dependent Variable: CO2				
Method: Fixed Effect Method				
Period Included: 33 (1997 – 2022)				
Cross-Section Included: 8				
Total Panel Observations: 216				
Variables	Coefficient	Std. Error	t-Statistic	Prob.
TO	0.039711	0.000567	0.699738	0.0049
FDI	0.017173	0.00413	1.736686	0.084
GDP	0.003986	0.001702	2.342709	0.0202
REC	-0.03837	0.000627	-6.11482	0.000
NREC	0.005801	0.002165	2.679169	0.008
C	0.373025	0.071737	5.199875	0.0000
CO2(-1)	0.794176	0.040574	19.57369	0.0000
R²		Adjusted R²	0.907473	
0.95826		Durbin-Watson Stat	2.00635	
F-Statistic				
1256.21				
Prob(F-statistic)	0.00000			

Source: Author's Calculations

The above table 8 also shows the value of R², adjusted R², F-statistics, Durbin Watson and probability(F-statistic). R² explain the variation in the dependent variable that is explained by independent variables. The range of R² lies between 0 to 1. If the value of R square is close to zero the model is not good fit. If the value is close to 1 the model is good fit for the analysis.

The value in above table shows that 95.82% dependent variable is explained by independent variables included in the model. This shows that the model is good fit. In multiple regression model Adjusted R square explains the limitation of R square. If we will add more variables in the model R square will increase but adjusted R square will explain the addition of unnecessary variables. Adjusted R square is less than R square.

The value of F- statistics is 1256.21 and probability value is 0.000 which is positive and significant. The probability value shows that the model is good for analysis. The Durbin Watson test is used to check the problem of auto correlation in the data set. The value of Durbin Watson test lies from 0 to 4. If the value is close to zero there is problem of autocorrelation, if the value is greater than 2 there is no autocorrelation. In above table the value of Durbin Watson test is 2.00635 which shows that there is no autocorrelation.

The results of model interaction term are presented in this section. This section presents that how government is effective in case of carbon emissions in south Asian developing countries. This model is an extension of model 3 so we have already checked the problem of autocorrelation, multicollinearity and hetero

Heteroskedasticity. So, the empirical results of the random fixed effect model will be present below.

Results of Fixed Effect Regression Analysis

The current study uses the fixed effect model for analysis. The current model will check the government effectiveness in case of carbon emission in South Asian countries. The results of model 2 is presented in table 9. The coefficient of trade openness shows positive and statistically significant (0.0398) impact on carbon emissions. If 1% increase in carbon emissions will leads to increase in 0.181918 carbon emissions. The coefficient of foreign direct investment is positive and statistically significant (0.0748) impact on carbon emissions. If 1% increase in foreign direct investment will increase 0.015515 in carbon emissions. The coefficient of gross domestic product is positive and statistically significant (0.0000) impact on carbon emissions. If 1% increase in gross domestic product will increase 0.146676 in carbon emissions. The value of coefficient of gross domestic product square is negative and statistically significant (0.0144) impact on carbon emissions. If 1% increase in gross domestic product square will decrease in carbon emissions by (-0.14176). The coefficient value of nonrenewable energy consumption is positive and statistically significant (0.0139) impact on carbon emissions. If 1% increase in non-renewable energy consumption will increase carbon emissions by 0.294713.

Table 9: The Results of Fixed Effects Regression Analysis Model

Dependent Variable: CO2				
Method: Fixed Effect Method				
Period Included: 33 (1997 – 2022)				
Cross-Section Included: 8				
Total Panel Observations: 216				
Variables	Coefficient	Std. Error	t-Statistic	Prob.
TO	0.181918	0.153378	0.253943	0.0398
FDI	0.015515	0.084231	1.014998	0.0748
GDP	0.146676	0.423285	5.494294	0.0000
GDP2	-0.14176	3.766201	-2.46858	0.0144
NREC	0.294713	0.096502	0.885315	0.0139
REC	-0.18692	0.456128	-3.06372	0.0025
TO*GE	-0.57279	0.410117	-1.45473	0.0062
CO2(-1)	0.901165	0.052248	17.248	0.0000
C	0.178075	0.088765	2.006145	0.0462
R²		Adjusted R²	0.984338	
0.985473		Durbin-Watson Stat	2.365718	
F-Statistic				
868.337				
Prob(F-statistic)	0.00000			

The coefficient value of renewable energy consumption is negative and statistically significant (0.0025) impact on carbon emissions. If 1% increase in renewable energy consumption will decrease carbon emission by (-0.18692). The coefficient value of interaction term government effectiveness and carbon emission is negative and statistically significant (0.0062) impact on carbon emissions. If 1% increase in government effectiveness will decrease carbon emissions by (-0.57279). If government is effective it will impose strict rules and regulation and there will be low environmental degradation.

The above table 09 also show the value of R^2 , adjusted R^2 , F-statistics, Durbin Watson and probability(F-statistic). R^2 explain the variation in the dependent variable that is explained by independent variables. The range of R^2 lies between 0 to 1. If the value of R square is close to zero the model is not good fit. If the value is close to 1 the model is good fit for the analysis. The value in above table shows that 98.54% dependent variable is explained by independent variables included in the model. This shows that the model is good fit. In multiple regression model Adjusted R square explains the limitation of R square. If we will add more variables in the model R square will increase but adjusted R square will explain the addition of unnecessary variables. Adjusted R square is less than R square. The value of F- statistics is 868.337 and probability value is 0.000 which is positive and significant. The probability value shows that the model is good for analysis. The Durbin Watson test is used to check the problem of auto correlation in the data set. The value of Durbin Watson test lies from 0 to 4. If the value is close to zero there is problem of autocorrelation, if the value is greater than 2 there is no autocorrelation. In above table the value of Durbin Watson test is 2.365718 which shows that there is no autocorrelation.

Conclusion and Policy Recommendation

This chapter explain the existence of pollution heaven hypothesis in south Asian developing countries for the period of 1997 to 2022. This study uses the fixed effect for analysis. The results showed that Trade openness, foreign direct investment, gross domestic product and non-renewable energy consumption are harmful for environment. Renewable energy consumption is environment friendly because there is decrease in carbon emissions due to renewable energy consumption. The results shows that there is existence of pollution heaven hypothesis in south Asian developing countries. It means that due to trade openness there is increase in carbon emission in south Asian countries. All the variables included in the model are positive and statistically significant except renewable energy consumption. The interaction term between trade openness and government effectiveness shows that if government is effectiveness in south Asian developing countries there will be decrease in carbon emissions. So if south Asian developing countries want to grow there should be environment friendly technologies. Because we can protect our environment just because of this. In case of trade and foreign direct investment there should be strict environmental rule and regulations in south Asian countries.

Policy Recommendations

Based on the empirical findings confirming the existence of the Pollution Haven Hypothesis in South Asian developing countries during the period 1997–2022, several policy implications emerge. Since trade openness, foreign direct investment, economic growth, and non-renewable energy consumption contribute significantly to environmental degradation, policymakers must adopt a balanced growth strategy that integrates economic development with environmental sustainability.

First, South Asian countries should strengthen their environmental regulatory frameworks, particularly in relation to trade and foreign direct investment. While openness to international trade and capital inflows is essential for economic growth, weak environmental standards can attract pollution-intensive industries. Therefore, governments should enforce stricter environmental regulations, mandatory environmental impact assessments, and compliance monitoring for both domestic and foreign firms. This would help prevent the relocation of environmentally harmful activities into the region.

Second, the promotion of renewable energy sources should be prioritized through targeted public policies. The empirical results indicate that renewable energy consumption reduces carbon emissions, highlighting its importance in achieving environmental sustainability. Governments should provide fiscal incentives such as tax exemptions, subsidies, and concessional financing to encourage investment in renewable energy technologies. Additionally, regional cooperation in renewable energy development can help reduce costs and improve energy security.

Third, improving government effectiveness plays a critical role in mitigating environmental degradation. The interaction between trade openness and government effectiveness suggests that stronger institutional quality can offset the negative environmental effects of globalization. Policymakers should therefore focus on enhancing governance quality by improving regulatory enforcement, reducing corruption, strengthening institutional capacity, and ensuring transparency in environmental policymaking.

Fourth, economic growth strategies in South Asia should shift toward environmentally friendly and energy-efficient technologies. Governments should encourage industries to adopt cleaner production methods through green financing mechanisms, technology transfer agreements, and environmental performance standards. Supporting research and development in green technologies can further facilitate a transition toward sustainable growth.

Finally, public awareness and regional coordination should be strengthened to address transboundary environmental challenges. Climate change and pollution are not confined to national borders; therefore, South Asian countries should collaborate on environmental policies, information sharing, and joint climate initiatives. Coordinated regional efforts can improve policy effectiveness and help achieve long-term environmental sustainability.

In conclusion, sustainable economic growth in South Asian developing countries requires a comprehensive policy approach that integrates trade, investment, energy, and institutional reforms. By promoting renewable energy, strengthening

environmental regulations, and improving government effectiveness, policymakers can reduce carbon emissions while maintaining economic growth.

Future Research Directions

Although this study provides important empirical evidence on the Pollution Haven Hypothesis in South Asian developing countries, several avenues remain open for future research. First, future studies may extend the analysis by incorporating additional environmental indicators beyond carbon emissions, such as ecological footprint, particulate matter (PM_{2.5}), or water pollution measures. This would allow for a more comprehensive understanding of environmental degradation associated with trade and investment activities.

Second, future research could examine the role of sectoral composition in shaping environmental outcomes. Disaggregating foreign direct investment and trade flows into manufacturing, energy, agriculture, and services sectors may reveal whether pollution-intensive industries are more responsive to trade liberalization and weak environmental regulations. Such sector-specific analysis would provide deeper insights into the mechanisms underlying the Pollution Haven Hypothesis.

Third, further studies may employ alternative econometric techniques to capture dynamic and nonlinear relationships among economic growth, energy consumption, trade openness, and environmental quality. Methods such as dynamic panel models, threshold regressions, or spatial econometric approaches could offer additional perspectives, particularly in the presence of cross-country spillover effects and regional interdependence.

Fourth, future research could explore the moderating role of institutional and governance factors in greater depth. While this study considers government effectiveness, other dimensions of governance—such as regulatory quality, rule of law, political stability, and control of corruption—may also influence the relationship between globalization and environmental degradation. Comparing the relative importance of these institutional indicators would enhance policy relevance.

Finally, future studies may consider expanding the geographical scope or time coverage of the analysis. Comparative studies between South Asia and other developing regions, or country-specific time-series analyses, could help identify heterogeneous effects and country-level policy lessons. Additionally, incorporating post-pandemic data may provide insights into how global economic shocks affect the trade–environment nexus.

Overall, future research building on these directions can contribute to a more nuanced understanding of sustainable development challenges and support the formulation of effective environmental and economic policies in developing economies.

Acknowledgment= Comments from the editor and the anonymous referees are gratefully acknowledged.

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Statement and Declaration: The topic of this article is “The impact of trade openness on environmental degradation and role of government in south Asian developing countries. This is original work done by the authors. Farrukh Ishtiaq is first and corresponding author and Deng Aimin is second author.

Ethical Approval: This study is related to social science and it is not related to human or animal study.

Consent to participate: This research is original and there is no issue related to this research.

Consent to publish: This manuscript has not been published in any journal and it is not submitted for publication in any other journal.

Author contribution: Farukh Ishtiaq wrote introduction, literature review, collected data and designed the model and write up the paper. Deng Aimin was responsible for supervising the analysis and editing the work.

Funding: There is no funding form any organization for this research.

Competing interests: The authors don't have any financial or non-financial interests.

Data availability: Data will be available on special request.